

Is the Earth surface denudation operating at steady state?

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The most prominent geochemical effect of rock weathering is to partition chemical elements and their isotopes between surface waters and residual solids. This makes chemical and isotope fractionation prime tools for tracing weathering processes and quantifying associated fluxes of matter at the Earth surface. However, the sound interpretation of these tools requires a mathematical framework. The most simple framework hinges on steady state mass balances [1]. Finding the solutions of these systems is usually straightforward, and only a few number of adjustable parameters are required compared to more complex modeling approaches. This type of mass balances has been applied to weathering systems from the scale of soils [2] to that of rivers [3]. However, this steady state hypothesis requires rigorous testing. At soil and small river scales, such evaluations are hampered by difficulties in obtaining representative chemical compositions for weathering products, due to temporal variability and grain size effects [1]. At the large river scale these difficulties are minimized [4]. Yet, when steady state mass balance equations for Earth surface denudation based on major element are solved for erosion rates at the large river scale, predicted erosion rates significantly overestimate those measured by sediment gauging and cosmogenic nuclides [3,5]. Indeed one issue with large scale steady state mass balance is the estimation of the chemical composition of the parent rock. In particular, the prominent role played by metasedimentary rocks in Earth surface denudation [6] potentially explain the mismatch between predicted and measured erosion rates [3]. Using Li isotopes to accurately estimate the chemical and isotope composition of the continental crust drained by the Amazon River (i.e. taking into account the role of metasedimentary rocks), we show that predicted and measured erosion rates do agree for the largest river system on Earth.

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